Advanced method for continuous denoising of far-field arm-ECG bipolar lead data using empirical mode decomposition

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Abstract—The ability to noninvasively monitor heart rhythm in a home care environment is limited by the current ECG signal denoising techniques that can facilitate a robust and stable detection and analysis of heart rhythm, from a far-field bipolar lead, located along the left arm (a comfort zone)', offering patient compliance clinical advantages. Empirical mode decomposition (EMD) has been identified as an effective method of fast signal extraction and noise reduction for far-field recorded arm-ECGs. The following work discusses a technique that allows the EMD method to run on a live data stream and provide a filtered stream with latency of less than one second.

I. INTRODUCTION

The current approach to EMD data manipulation requires a static, or discrete data set [1]. The rules of EMD are then applied, as in (1, 2), and a decomposed variant of the original signal obtained.

$$h_{1-n}(t) = x(t) - m_{1-n}(t) \qquad (1)$$

$$r_1(t) = x(t) - C_1(t) \qquad (2)$$

The original signal may be reconstructed by the addition of the intrinsic mode functions (IMFs) and the residual component. This allows for partial recomposition and strategic filtering of the original data to take place [2]. The EMD technique differs from bandwidth suppression as it is data, rather than frequency driven and, as such, allows for better retention of the original signal morphology [3].

The nature of the technique means that the IMF bin contents are not consistent. Hence, the application of this filter protocol to a different discrete set of data, may return a set of IMF bins with baseline drift information located differently.

II. METHODS

A blended approach, including Fourier analysis, is used in order to enhance the conventional EMD method. Figure 1 depicts the proposed protocol incorporating this methodology. The critical practical implication of this approach is the processing overhead. While substantial, it is not sufficient to add latency of greater than 1 second, allowing this technique to perform within the definition of what may be considered to be 'real-time' [1] detection algorithm.

III. RESULTS AND CONCLUSION

The table within Figure 2 shows a comparison made between the output of the proposed EMD denoising filter and the more conventional and clinically accepted Signal Averaged ECG (SAECG) denoising method; used here as the control method for experimental purpose [4], as in practice, is not feasible for our intended application. The processed data using MATLAB, shows the proposed EMD approach to be an improvement over the SAECG control method in some cases. The signal-to-noise ratio (SNR) of Subject 10 appears to have reduced markedly, however the authors noted a considerable improvement in the morphology of the denoised ECG.

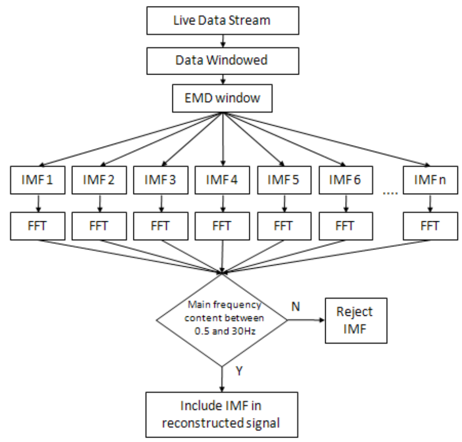
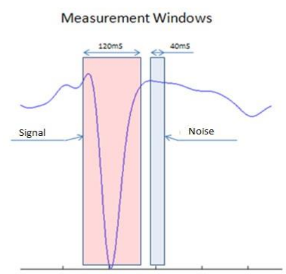


Figure 1. Dynamic EMD filter structure.



(a)

Best Case recordings from CAH database		
Subject	SNR Bicep pair Ch12-11	
	Sig Avg	Dynamic EMD
1	1.27	1.36
2	4.93	5.23
3	36.86	28.7
10	197.1	56.3
17	1.49	2.51
36	3.6	3.45

(b)

Figure 2. (a) Measurement window locations on extracted wave form. (b) Signal to Noise Ratio comparison between SAECG and Dynamic EMD.

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